CHAPTER 5

Environmental Technology

Improving environmental performance while keeping regulatory compliance costs at a minimum is one of the key challenges affecting the future competitiveness of metalcasters. How well the industry copes with increasingly stringent controls on emissions to the environment will have dramatic impacts on production costs as well as industry growth. The issues of environmental compliance will be further complicated as manufacturing practices change to meet market demand for new casting products and to reflect changes in customer needs.

Current Situation

Metalcasting produces a number of gaseous, liquid and solid waste streams (shown in Exhibit 5-1 for ferrous casting processes), many of which could have an adverse effect on the environment. Waste products from casting operations include waste gases from molding and core making, melting, molding, and shakeout; contaminated and unusable spent sand from sand casting shakeout; slag from melting; and particulate from melting, shakeout, and cleaning. Air-borne pollutants and contaminants also present a major environmental issue for all metalcasters. These include dust, particulate, off-gases, fumes, and gases (such as carbon monoxide) from furnaces, and other byproduct gases and fugitive emissions.

Metalcasting also produces some very positive impacts on the environment by preventing the landfilling of large amounts of scrap metal. The foundry industry is one of the largest recyclers in North America, saving 13.3 million tons of scrap metal from disposal every year. Scrap iron and steel are currently used to produce at least 85% of all ferrous castings in the United States.

The waste streams produced by metalcasting are subject to compliance with a number of environmental regulations governing air, water, and solid waste effluents. Major environmental statutes and regulations affecting the metalcasting industry include the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), and the Superfund Amendments and Reauthorization Act (see Exhibit 5-2). Of these, the Clean Air Act Amendments of 1990 pose the most difficult and costly near-term challenge.

The foundry industry spends over $1.25 billion per year to comply with Federal, state, and local government regulations. The Department of Commerce reports spending of nearly $330 million in 1994 in operating costs for pollution abatement and control, although this does not include some smaller foundries, certain categories of environmental compliance costs, and pollution control costs from captive foundries reported under different industry classifications.

Exhibit 5-1. Foundry Solid Waste Stream Estimates (Ferrous)				
Waste	**Generation Process**	**Average Waste Generation in 1989 (tons)**	**Production Rate (ton waste/ ton casting)**	**Percent of Solid Waste Stream (%)**
Spent sand (non-hazardous)	Shakeout	8,093	0.384	57
Spent sand (hazardous)	Shakeout	165	0.008	1
Slag	Melting	3,695	0.175	26
Particulate	Melting, Shakeout, and Blast Cleaning	2,272	0.107	16
TOTAL		**15,073**	**0.674**	**100**

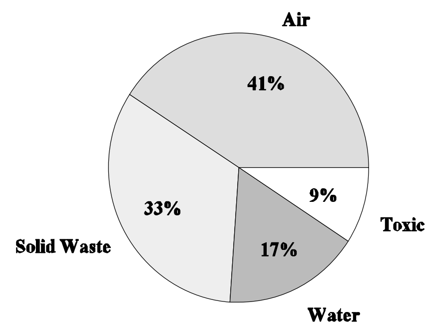
Source: *Environmental Compliance in the Foundry Industry*, Energetics, Inc., June 1995.

Exhibit 5-2. Major Environmental Statutes Affecting U.S. Foundries		
Statute	**Target Waste Stream**	**General Requirements**
Clean Air Act	Particulate, hazardous air pollutants	Emission control equipment, monitoring, reporting, and permits
Clean Water Act	Wastewater from scrubbers for emission control and storm run-off	Pre-treatment of waste- and storm water prior to discharge, discharge limits, and permitting program for discharges
Resource Conservation & Recovery Act (RCRA), Subtitles C&D	Spent sand and slag with RCRA-characteristic waste	Restrictions on transport, storage, and disposal (e.g., land disposal); RCRA permit
Superfund Amendments & Reauthorization Act (SARA) Title III	All waste streams of releases (spent sand, slag, particulate, sludge, wastewater, etc.) containing a Section 313 (toxic) chemical	Record keeping on the types and amounts of emissions and reporting on an annual basis

Source: *Environmental Compliance in the Foundry Industry*, Energetics, Inc., June 1995.

About 40% of compliance costs are used for control, treatment, and disposal of air pollutants and related sludges. Solid and hazardous waste disposal -- mostly sands and slags -- account for about 33% of compliance costs (Exhibit 5-3). It is estimated that environmental compliance costs represent 2% of the cost of a casting. New environmental regulations are expected to increase this portion to 5% of casting costs in the near future. In terms of new capital expenditures, it has been estimated that environmental expenditures consume as much as 30 to 60% of total annual spending for the foundry industry.

Ex 5-3. Environmental Cost by Media



Trends and Drivers

The metalcasting industry has been struggling with environmental regulation and compliance issues for decades. Surveys of U.S. foundries indicate that environment, health, and safety issues -- and the regulations that govern these areas -- are the top concerns facing the future of their businesses. It has been estimated that the cost of compliance to metalcasters has been at least partly responsible for the demise of about 2,000 metalcasting firms over the last twenty years. Smaller foundries (which comprise more than 80% of the industry) can least afford to deal with environmental costs and are usually the hardest hit by new regulations. Increased compliance costs fall disproportionally on smaller foundries, continuing the shutdown of marginal small foundries and the trend toward larger facilities.

Environmental regulations are expected to become increasingly strict over the next two decades and will have significant impacts on metalcasters in terms of cost and economic viability. EPA is currently involved in rulemaking under the Clean Air Act Amendment (CAAA) of 1990 that will directly affect U.S. foundries. The new regulations, which are scheduled for enactment in the year 2000, will enforce new environmental standards for iron and steel foundries. Implementing these new regulations is expected to increase environmental compliance costs by $750 million over the next five years.

Sand casters face major environmental issues related to treatment and disposal of spent sands that may be contaminated with toxic or hazardous wastes. RCRA Subtitle D restrictions on non-hazardous wastes is expected to cause a large percentage of existing landfills to close, increasing the cost of treatment and disposal by $13 per ton, or about 20% of the current life-cycle cost of sand.

Technologies that reduce or eliminate waste and improve performance will greatly enhance the future success and world-wide competitiveness of the industry. In the international market, domestic metal castings must sometimes compete with castings produced in countries with less demanding environmental standards and where the cost of environmental control is far less. To stay competitive and cope with the rising cost of environmental compliance, metalcasters have begun to examine ways to reduce waste generation at the source as well as increase utilization of waste and byproducts. In many cases, capital funds are diverted to compliance with regulations (end-of-the-pipe command and control) rather than development of technologies or strategies to reduce, eliminate, or utilize waste products. However, some new technologies and materials are being investigated, including non-toxic binders, sand reclamation systems, and air and water purification systems, all of which have made important contributions to cleaning up metalcasting processes. In addition, metalcasters have been working with some success to develop new alloys that have less environmental impacts (e.g., alternates to lead-bearing copper alloys).

Performance Targets

In *Beyond 2000: A Vision for the American Metalcasting Industry*, the industry identified long-term targets to improve its overall environmental performance and to become publicly recognized for responsible environmental management practices:

- Achieve 100% pre- and post-consumer recycling
- Achieve 75% re-use of foundry byproducts
- Eliminate waste streams completely

Some industry representatives have indicated that a target of 100% pre- and post-consumer recycling is probably unrealistic. The reasoning here is that the *theoretical* maximum is closer to 95%, and achieving the theoretical maximum recycling rate would be difficult and costly. In addition, to reduce confusion about "eliminating" waste streams (e.g., determining what is characterized as a "waste" and handling products that are process "wastes" but can be beneficially reused), an alternative goal of achieving "zero discharge" levels has been proposed.

The chief drivers of environmental performance goals are regulation and economics. Significant further advances in environmental technologies will thus be motivated by government regulations or clear cost savings potential.

Technology Barriers

Metalcasters have been facing serious environmental challenges for the last two decades, and have made some headway in learning how to comply with the growing profusion of regulations. However, there are still many impediments to the environmental progress of this industry, many of which are associated with the fractionated, small-business nature of metalcasting. For example, to create long-term solutions, metalcasters must invest in R&D and information gathering that will meet long-term goals (e.g., eliminating waste streams entirely, or increasing recycling of foundry products) along with compliance. This has been difficult for many foundries, most of which are small businesses with limited funds for capital expenditures or research of any kind. When faced with large fines or plant closures due to non-compliance, many are forced to invest in compliance and control rather than reduction or elimination strategies.

Exhibit 5-4 shows other environmental technology barriers that currently prevent the industry from achieving its environmental goals. These barriers are categorized as waste characterization, waste utilization, technological, and institutional.

The ability to develop effective approaches to environmental problems must be based on a comprehensive **characterization** of foundry waste streams, an analysis which has not yet been performed. A full characterization could identify missed opportunities for beneficial reuse of waste and help overcome the concern of potential users of the waste byproducts.

There is a severe lack of data on foundry emissions and currently used and best available control technology. For example, if data were available to adequately assess the environmental impact of mold/core binders or other sand additives, the environmental impact of the casting process could be optimized while at the same time maintaining world-class quality for castings. Data to properly select the technology to produce or deliver molten metal to molds would minimize the environmental impact of the casting process while at the same time maintaining world-class quality for castings.

Exhibit 5-4. Major Environmental Technology Barriers
(Most Critical Barriers Boldfaced)

AREA	BARRIERS
Waste Characterization	**Lack of waste stream characterization** Lack of data to adequately assess the environmental impact of mold/core binders or other sand additives Lack of data to properly select the technology to produce or deliver molten metal to molds Lack of information on the redesign and reconfiguration of common foundry processes, tools, equipment, and materials to reduce cumulative trauma Lack of systems to identify scrap at early stages of process where value-added component is low Lack of understanding of the public health effects of trace elements
Waste Utilization	Opportunities for the use of foundry residuals as substitutes for other raw materials used in processes in other industries are not well known or understood Presence of long-lived materials in waste streams Lack of methods for removing zinc and waste oil from water in a usable way Lack of identification system for materials recycling Large number of alloys used makes post-consumer recycling tougher Concerns of potential users about using waste stream by products Lack of viable uses for waste streams Provisions that pull inert materials into a hazardous waste regulatory framework Identification and application of environmental solutions is a moving target
Technological	Aluminum sticks to steel in die casting - requires use of die lubricants Lack of technologies for recovery of low-temperature waste heat
Institutional	**Lack of educated workforce** **Enviromental requirements often based on social rather than technical considerations** Capital costs of sand recycling for small founders

Waste utilization barriers include a lack of knowledge of the potential uses of foundry residuals as substitutes for other raw materials and the lack of viable uses of waste streams. The large number of alloys used makes post-consumer recycling more difficult, compounded by the lack of a comprehensive materials identification system. In addition, no economical technologies currently exist to recover usable waste oil and zinc from water.

Foundries are adversely impacted by provisions that pull inert materials into a hazardous waste regulatory framework. Certain RCRA provisions (e.g., restrictions on scrap metal consumers, new requirements for industrial non-hazardous waste, mandated toxics use reduction) could discourage the beneficial re-use of non-hazardous materials.

Long-term changes in the composition and manufacturing practices of the metalcasting industry make the identification and application of environmental solutions a moving target. The industry should consider developing effective and resilient strategies for the application of pollution prevention technologies to respond to both long-term environmental and market needs.

Many of the barriers listed under waste utilization are also **technological** barriers, such as the separation of zinc and waste oil from water. Some additional technological barriers include the lack of technologies for recovering low-temperature waste heat from metalcasting processes and the inability to die cast aluminum without using lubricants because of problems with sticking.

The **institutional** side of environmental management also presents barriers to environmental technology improvements. For example, regulatory requirements are often shaped by social, not technical, considerations. An important crosscutting barrier to achieving the industry's long-term goals in environment as well as other areas is the lack of a technically educated work force.

Research Needs

A wide range of research and development is needed to overcome existing barriers to achieving the metalcasting industry's manufacturing and environmental technology goals. These needs are depicted in Exhibit 5-5, which shows the R&D needs by subject category and distributed by the expected time frame (near, mid, or long) for completion of the research. To produce castings in a more environmentally sound manner, the industry needs to understand the nature of its waste streams, develop viable uses for byproducts, and investigate ways to reduce and eliminate waste streams.

A near-term effort to compile a database of environmental emissions for foundry and die casting processes would provide environmental regulators with better baseline information that could be used in setting more effective standards. **Characterization** of all material flows and waste streams in the production process would allow the industry to better understand the sources and magnitudes of wastes and pollution. Foundry processes could be **modeled** to identify and minimize environmental problems in both the design phase as well as during operation.

Waste utilization R&D activities could include investigation of potential beneficial uses of spent foundry sand and other products such as spent baghouse dust, iron oxide, sludges, slags, and waste oils. Over the longer term, research is needed to identify new uses for known waste streams and/or new ways to treat waste streams to make them more usable. New energy-efficient sand reclamation technologies could be developed, as well as low-cost production mold technologies that facilitate recycling.

In general, the development of both new processes and new materials that could minimize or eliminate the generation of certain foundry wastes is considered a priority area for research. **New processes** could include in-process recycling, closed-loop water systems, and low-cost waste treatment technologies. In addition to developing new technologies, the industry could attempt to optimize existing technologies through improved control or other methods to reduce waste generation.

Exhibit 5-5. R&D Needs in Environmental Technologies (**k** = Top Priority; **M** = High Priority; **F** = Medium Priority)					
Time Frame	**Waste Characterization**	**Modeling**	**Waste Utilization**	**Waste Reduction - Processes**	**Waste Reduction - Materials**
NEAR (0-3 Years)	**M** Develop emissions database for foundries to use in educating regulators Characterize all material flows and waste streams in the production process		Investigate beneficial uses of spent foundry sand and other waste products for applications in other industries - baghouse materials - iron oxide - wet collector sludge - slag - machining oils	Improve or optimize existing processes to reduce or prevent the production of wastes - improved process control	
MID (3-10 Years)			**M** Develop new markets for foundry byproducts Develop new energy-efficient concepts in sand reclamation	**M** Develop new processes to reduce or prevent the production of wastes - in-process recycling - closed-loop water systems - low-cost treatment technologies	**k** Develop environmentally benign, dimensionally stable molding materials for sand casting - sand molding or core systems with low or no emissions Develop/exploit new materials to reduce or prevent the production of wastes - charge materials
LONG (>10 Years)		**F** Model foundry processes to identify and minimize environmental problems in both the design and operation stage	Develop low-cost production mold technologies (vs. prototype) - cheaper ways to make and/or recycle molds - disposable?		**F** Develop material that adheres to dies and does not have to be replaced each cycle

New materials could include environmentally benign sand binders as well as additives and charge materials. The development of these types of materials (achievable in the mid term) and the development of low-cost materials that adhere to dies and don't have to replaced each cycle (achievable in the long term) are expected to be undertaken by vendors in response either to government regulation or to the market demand for the products by the metalcasting industry. However, there is some concern as to whether research on environmentally benign binders can be adequately addressed by the private sector alone.

Potential Government Role

The overwhelming majority of the research needs are unlikely to be pursued by industry in the absence of government funding support. Because the majority of the metalcasting industry is composed of small companies with very limited R&D budgets and in-house research facilities, all but the "business-critical" R&D will probably not be funded or performed by individual companies. Furthermore, to maintain the metalcasting industry's international competitiveness, much of the identified R&D is required more quickly than industry can support on its own. Therefore it is essential that industry leverage its R&D activities by partnering with outside agencies to remain competitive.